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ATA OPERATIONS

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INTRODUCTION

During the charged particle beam propagation experiments run on ATA in December 1985, we found experimentally that four accelerator parameters controlled the condition of the electron beam entering the IFR.

ACCELERATOR CONFIGURATION

Throughout the experiments the accelerator was configured as shown in Fig. 1. The cathodes used in the injector were field emission cathodes made from velvet cloth. We used two sizes of cathodes, a 7 inch diameter cathode that produced 12-14 ka out of the injector and a 5 inch diameter cathode that produce 9-10 ka. Because we had difficulties matching currents greater than about 10 ka nt the ion channel, most of our data was taken using the smaller cathode. The transport of the e-beam through the accelerator and transport section was done using laser guiding, using benzene as the ionized medium. The benzene channel typically ran through the accelerator and the entire transport section to the IFR. In order of use the energy analyzing magnet, which was located at about 16 meters in the transport section, we had to have the ability to pump out the benzene in this area. We installed a section of beam pipe with a reduced diameter (2 inches) at the 7 meter mark in the transport section. Using this flow restrictor, we could differentially pump the benzene and lower the pressure on the downstream side of the restriction. The flow restrictor also acted as a beam diagnostic in that any beam that would not pass through it was larger than 2 inches in diameter.

PARAMETERS AFFECTING BEAM CONDITION

The first parameter that affects the beam condition is the matching of the e-beam onto the laser produced ion channel. This matching was done at the low energy end of the accelerator, usually at about cell 20. The matching was done by lowering the magnetic field in the area where we began to introduce the benzene. The matching was characterized by a large (more than 1 cm) offset in the beam centroid. This offset was probably due to a misalignment between the magnetic and optical axes of the machine. By carefully adjusting the steering and focusing of the beam we could minimize the displacement of the beam centroid. A poor match (large centroid motion) led to a decrease in the total current transported. Also, because the coherent centroid motion damped out due to phase mixing within one cell block (3 meters), a poor match led to an increase in beam emittance.

The next parameter affecting the beam was the laser timing with respect to the e-beam. If the laser was fired earlier than the e-beam, we would develop an excess of laser induced current. This extra current preceded the cathode current by a few nano-seconds, was characterized by a large spread in energy and a low emittance. While experimenting with the laser timing we found we could only transport about 30 ns of pulse width before the tail of the pulse started to grow in the radial dimension. This was obvious as we tried to propagate the beam through the 2 inch diameter benzene restrictor. We were surprised to find that the tail of the beam was being scrapped by the 2 inch pipe while the beam size should have been a few millimeters. TV data at the entrance foil to the IFR confirmed that the radius of the beam was growing through the pulse but we were never able to see images as large as 2 inches in diameter. It is possible that the current density on the foil was so low that we could no longer detect it. By controlling the laser timing we could control the total pulse width, the growth of the pulse in time, and the mixture of laser current and cathode current.

Another parameter controlling beam conditions was the pressure profile of the benzene at the entrance to the IFR. By controlling the benzene pressure we could affect the focusing strength of the ion channel and thus the size of the e-beam at the foil. Most of the data taken during December was taken with the benzene pressure lowered in front of the foil to allow the beam to expand prior to entering the IFR.

Finally, the timing of the accelerator gap voltages with respect to the e-beam was found to control the energy distribution of the cathode current. If the gaps were fired too early, then the head of the e-beam was on the flat section of the accelerating pulse but the tail was on the section of decreasing voltage. This produced a beam with a large energy variation in the tail of the beam. The opposite case could be produced by firing the gaps too late.

CONCLUSION

We have found four parameters for controlling the conditions of the beam entering the IFR. These parameters are the matching to the ion channel, the laser timing, the benzene pressure, and the timing of the accelerator gaps. Using these parameters we were able to control the total current, the emittance, the pulse length, the mixture of laser induced current and cathode current, the radial growth in time, the final size of the beam, and the energy variation through the pulse. Due to a lack of time during the experiment we were not able to systematically study each of these areas. In future experiments we would be well advised to spend the effort to completely study the effects of these accelerator parameters.

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Accelerator configuration — December 1985

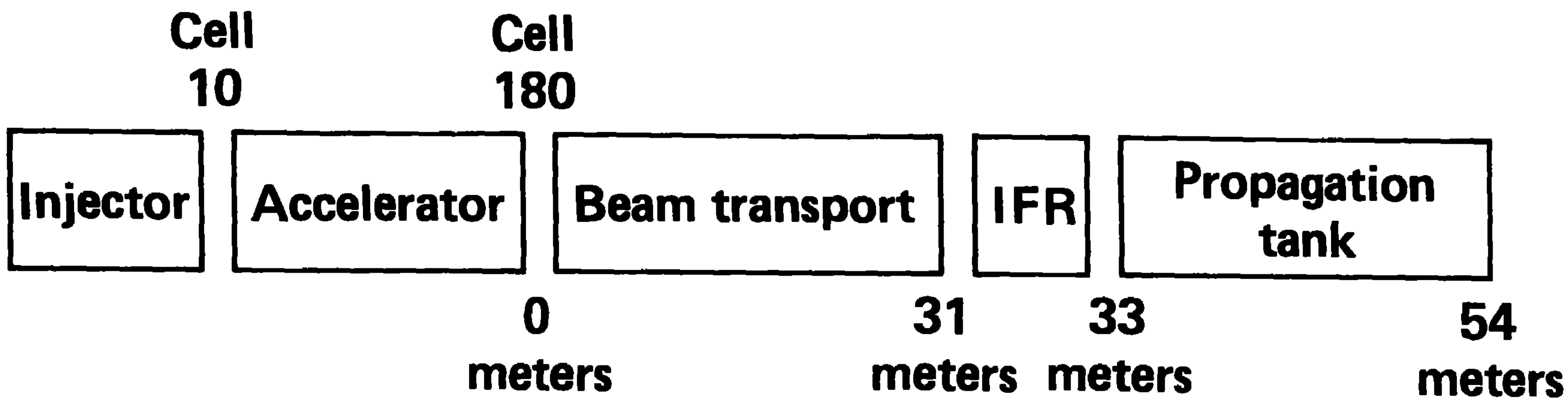

Figure 1